Air-derived Noble Gases In Sediments: Implications for Basin-Scale Hydrogeology

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RESEARCH OBJECTIVES

The goal of this project is to isolate and identify the various air-derived noble gas components in sediments, particularly (but not exclusively) those sediments associated with hydrocarbon systems. This project is designed to address how noble gas elemental patterns are acquired and retained in rocks and minerals and how they are transferred to the fluid phases in which they have been measured.

APPROACH

Laboratory and theoretical studies are carried out to (1) identify and isolate the carrier phases of the various air-derived noble gas components in sedimentary rocks and minerals, (2) investigate the process(es) responsible for acquisition and subsequent trapping of the components in their sedimentary carrier phases, and (3) evaluate the mechanisms that release these noble gas components to the ambient hydrological system under temperatures and pressures encountered in natural basin processes.

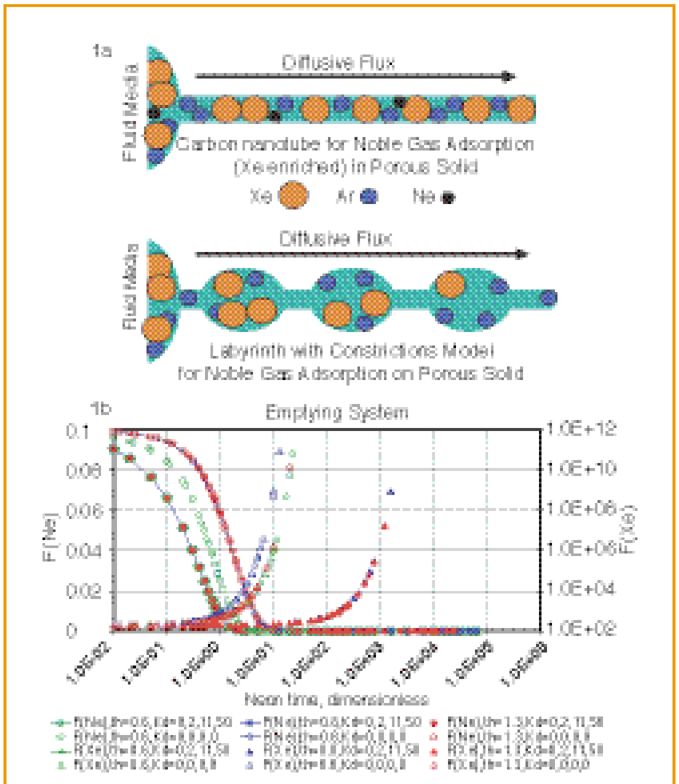

Figure 1: (a) Cartoons depicting the diffusive flow of noble gases through an angstrom-scale half-space (carbon nanotube) and a system of labyrinths and constrictions; (b) relative enrichment/depletion of noble gases as a function of time and effective diffusivities (Kd) and throat constriction diameters (th). The F(Ne,Xe) values are the abundances of Ne and Xe with respect to Ar, normalized to the Ne,Xe/Ar ratios in air.

ACCOMPLISHMENTS

We have examined adsorption and diffusion-controlled fractionation of noble gases as an explanation for the absolute and relative abundances observed in sedimentary rocks. The model uses diffusive filling and emptying of (1) angstrom-scale half spaces and (2) a system of labyrinths-with-constrictions on the order of the diffusing species' atomic diameter (Figure 1a). Since physical properties of the noble gases are strong functions of atomic mass, the individual diffusion coefficients, adsorption coefficients, and atomic diameters combine to enhance the transport of neon (Ne) while impeding xenon (Xe) (Figure 1b).

SIGNIFICANCE OF FINDINGS

The model results compare favorably with literature data for noble gas concentrations and relative abundances in terrestrial rocks. It is generally assumed that the source for all atmospheric noble gases in subsurface fluids is air-saturated water. Evidence for water-derived noble gases in hydrocarbon systems is extensive and provides strong support that water plays an important role in hydrocarbon systems. However, excesses of atmospheric xenon and neon recently identified in hydrocarbon systems may be derived from the source and reservoir rocks associated with the system (Torgersen and Kennedy, 1999; Kennedy et al., 2002). If so, future noble gas studies of fluid sources and flow will have to consider sediments as potential sources for atmospheric noble gases, which up till now have been mostly ignored.

RELATED PUBLICATIONS

Torgersen, T., and B.M. Kennedy., Air-Xe enrichments in Elk Hills oil field gases: Role of water in migration and storage. Earth Planet. Sci. Lett., 167, 239–253, 1999.

Kennedy, B.M., T. Torgersen, and M.C. van Soest, Multiple atmospheric noble gas components in hydrocarbon reservoirs: A study of the Northwest Shelf, Delaware Basin, SE New Mexico. Geochim Cosmochim Acta., 66, 2807–2822, 2002.

ACKNOWLEDGMENTS

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